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Prefiguring energy futures: Hybrid energy initiatives and just transitions in fossil fuel regions

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ABSTRACT

Energy transition, as both a material process and a process of reimagining energy futures, offers fertile grounds for broad societal transformation. However, the current state of power and politics in the historical fossil fuel regions of North America presents unique challenges. This paper explores initiatives that leverage former fossil fuels sites, infrastructure, and labor for renewable energy projects, and examines their position in prefiguring alternative energy futures in fossil fuel regions. These initiatives, which we introduce as hybrid energy initiatives (HEIs), can alleviate material, political, and cultural barriers to energy transitions by accounting for present contexts in regions of historical fossil fuel extraction, developing partnerships between renewable energy advocates and traditional fossil fuel stakeholders, and building legitimacy through discourses of equity and justice. However, discourses and technologies do not guarantee the operationalization of the just transition narratives HEIs often draw upon. We illustrate this in two case studies of initiatives, one in Appalachia, USA, and the other in Alberta, Canada, that position themselves as innovative endeavors in the utilization of former fossil fuel sites and infrastructures for new solar energy projects. Contributing to just transition scholarship we demonstrate an approach for considering the prefiguring potential of energy innovations and how elements of energy justice can be rendered acceptable within a political climate unfavorable to climate and just transition policies.

1. Introduction

> The mountain is poised for another transformation. Hundreds of acres are set to be blanketed with solar panels in the coming year, installed by locals, many of them former miners. The $231 million project, which recently cleared its last regulatory hurdle, may well be the biggest utility-scale coal to solar project in the country.
> -New York Times, January 2022

The above quote refers to the conversion of a former coal mine in Kentucky to a utility scale solar energy facility. The Martiki coal mine was active in Martin County along the West Virginian border up until the 1990's and was an important source of employment and economic activity for nearby communities in one of the poorest counties in the United States. The mine was a surface mine using mountaintop removal, a highly controversial and environmentally destructive technique that produces deforestation, habitat destruction, soil erosion, and persistent water quality issues. However, the mountain top removal process also created a level surface, a favorable location for a solar project in the otherwise steep hills and deep valleys of the Appalachian region.

The use of former fossil fuel landscapes as the backdrop for imagining alternative energy futures lends to an optimistic narrative. The symbols of a society that used and abused lands and peoples for the extraction and production of energy, whose consumption has created modern day's most pressing global crises, are transformed into visions of thriving and sustainable communities. Fossil fuel workers are reemployed and recast as environmental stewards, and energy companies and developers reaffirm a version of capitalism that is indeed 'green' and caring. These are visions of a just transition through which energy initiatives gain social legitimacy. However, these initiatives do not always lend to the enactment of a more just future. At times the optimistic narratives they employ are merely distractions from a continuation of the status quo.

Our aim with this article is two-fold. We explore how hybrid energy initiatives (HEIs)—initiatives that leverage former fossil fuel sites, infrastructure, and labor for renewable energy projects—are framed

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within narratives of just transition. HEIs, as sociotechnical innovations, can help build material and cultural bridges between the fossil fuel dominated past and renewable energy futures within a regional politic unfavorable to climate action. However, with case studies we also demonstrate how HEI's can either disrupt or sustain current extractive practices in energy development. Therefore, we make a case for paying careful attention to the futures these energy innovations are prefiguring.

Discourses of just transitions make clear that simply addressing the negative material impacts of an extractive economy does not inherently correct exploitative processes or entail the creation of just societies. In this way, just transition movements challenge unequal and exploitative systems of power as communities move to renewable sources of energy production and reduced consumption [1]. Having strong roots in labor organizing, many just transitions movements also acknowledge the complexities of longstanding cultural identities deeply tied to industries or specific economic models [2]. This is particularly important in regions with histories of fossil fuel production, where building support for alternative energy projects requires navigating certain material, political and cultural contexts that are co-produced with fossil fuel landscapes.

While just transition movements have pulled the necessity of acknowledging past harms and visioning better futures into wider conversations of renewable energy development, energy transitions in fossil fuel regions still face challenges building public and political support [3–5]. This can be seen in the historical energy producing centers of Canada and the United States. These regions are often dominated by conservative politics tied to support for the fossil fuel industry and that at times even promote hostility toward renewable energies [6]. From this vantage point, economies and livelihoods closely intertwined with the fossil fuel industry are positioned as at risk within energy transitions [7,8] and the production and consumption of fossil fuels is intentionally linked to cherished values, cultural norms, and identities [9]. These regions also share the physical scars of fossil fuel extraction, with networks of aging infrastructure and degraded lands [10]. Governments have repeatedly failed to hold the fossil fuel industry accountable for its damages [11,12], and boom and bust cycles create volatile economies for individuals and municipalities [13,14].

Narratives employed to legitimize energy transitions and their related projects must speak to the multifaceted and complex perspectives around energy as a polarizing political subject. Success in this regard has been demonstrated in the increasing popularity of HEIs. Examples of HEIs include initiatives to site renewable energy projects on former coal mines or to use inactive oil wells for geothermal energy production and battery storage. These novel energy innovations are able to nest within narratives of just transition by drawing on the histories of landscapes and people in fossil fuel economies. By utilizing former fossil fuel sites, infrastructure, and labor they are also able to garner the support of fossil fuel industry actors and their political allies in regions traditionally opposed to energy transitions.

With a focus on how HEIs narrate and operationalize just transitions in historical fossil fuel regions in Canada and the United States, this article addresses what Harris and McCarthy [15] theorize as the 'transit' of energy transition. The 'transit' of energy transition refers to the "discursive and material processes that shape how transition is framed, how it is implemented, and who stands to benefit from a more equitable energy system" [15]. Building on their work, we propose that the 'transit' of transition is also the space where future institutions can be prefigured, where it can be demonstrated how new structures might embody the values and ideals of energy justice. Furthermore, we point to HEIs as the vehicles through which these future institutions can be seeded while navigating the polarizing politics of energy.

We begin by presenting Alberta and Appalachia as fossil fuel regions to establish the context of our study and demonstrate why the material and cultural conditions in these regions create exemplary spaces for exploring the challenges to energy transition. We then introduce the prefigurative potential of energy innovations to frame our analysis. In our empirical work we show how HEIs are being positioned as initiatives able to address the unique challenges posed in fossil fuel regions. In two case studies of ongoing HEIs we demonstrate the specific ways in which these initiatives create legitimacy in fossil fuel regions, and where they are succeeding or failing to contribute to a just transition. We discuss the importance of energy initiative design and the ways in which each project prefigures an energy future in their approach to recognition, procedural and distributional energy justice.

2. The fossil fuel regions of Alberta and Appalachia

In the historical fossil fuel regions of Canada and the United States the embeddedness of fossil energy in the physical and cultural landscape is palpable. Traveling through Alberta, Canada's largest fossil fuel producing region, one might be met with views of flat yellow fields punctuated with pump jacks and the odd oil derrick, or possibly their symbolic re-creation in a small-town mural, on the uniform of a local sports team, or on the tail gate of a truck. In the Appalachian region of the Unites States, coal has made its mark both on the landscape and on the identities of the people who reside there [7,16]. You might see 'Friends of Coal' decals on trucks and t-shirts, county coal festivals, and coal themed tourist attractions throughout eastern Kentucky and southern West Virginia. These visual cues that you are indeed in a fossil fuel region are products of histories where livelihoods and communities have been intertwined with energy extraction since the 19th and 20th centuries, but also of intentional ideological manipulation on the part of the fossil fuel industry and its allies [17,18]. Fossil fuels are both materially and culturally embedded within historical fossil fuel regions - regions that now set the stage for energy transitions.

Within Alberta and Appalachia, the mining of coal and the drilling of oil and gas, alongside the networks of pipelines, storage tanks, and refining facilities are prominent on the physical landscape. As oil, gas, and coal economies mature or decline, aging infrastructure remains. This includes patchworks of seismic lines, unreclaimed and partially reclaimed mine sites, and hundreds of thousands of inactive oil and gas wells, many of which are 'orphaned' - having been left without decommissioning or clean up after a company has become insolvent. Not only do residents living in proximity to sites of fossil fuel extraction experience a wide array of direct and indirect health effects [19,20], these aging and defunct constituents of fossil fuels' past continue to create environmental hazards and human health risks through contaminations of soil and surface and groundwater, and leakages of methane, a potent greenhouse gas [21,22]. They also symbolize decades of corporate irresponsibility and poor regulation around decomissioning and remediation [23].

While the extraction of fossil fuels are often correlated with higher household incomes and employment rates at the regional level [24], working in fossil fuel industries is associated with particularly adverse health and well-being impacts [25–27]. Communities are also subject to dramatic swings known as the 'boom and bust' of fossil fuel economies. Global price volatility and resource exhaustion result in negative socioeconomic impacts such as job losses, losses in tax revenues, and reduced public services, and can ultimately be detrimental to economies pushed to depend on fossil fuels as a revenue stream [28,29].

In both Alberta and Appalachia fossil fuel extraction has also impacted the cultural landscape. While extractive industries can be a source of livelihood and pride for both workers and their communities, the ways by which communities came to depend on extraction has arisen through histories of dispossession and colonization in both regions [30–32]. Power and profit have always been central to the development of fossil fuel economies and scholars have studied how the fossil fuel industry continues to shape narrative and cultural identities to maintain the legitimacy of their practice [33]. Efforts to conflate fossil fuel interests with those of the individual, the region, and the nation have been heavily documented as a shared phenomenon in both regions [34–36]. This plays out in politics, with leading figures in the Canadian prairies

and Appalachia repeatedly taking aim at federal climate and environmental policy, positioning climate action as an attack on the regions and the people that have 'historically powered the nation' [18,37,38].

Framing fossil fuel development as a public good in need of defense against anti-industry environmentalists or governments has proven powerful within right wing populist politics [6]. Similar tactics are also present in primary and secondary education. Approaches to teaching about energy and climate change have been found to valorize fossil fuel industry interests, represent life without fossil fuels as a threat to modern freedoms, and reinforce the compatibility of continued fossil fuel production with environmental sustainability [39–41]. This discursive power combined with a material dependence on fossil fuel economies has created a distinctly petrocultural politic and social environment that hampers the deployment of renewable energy technologies [8].

3. Just transitions and the prefigurative potential of energy innovation

Harris and McCarthy [15] describe the discursive and material processes that shape energy transitions as the 'transit' of transition. Which energy futures are considered to be plausible and desirable is determined during the period of transit, as are the beneficiaries of the hopefully more equitable and lower carbon energy systems, and how the implementation of different technologies, policies and programs will unfold. Within this 'transit,', frameworks of just transitions and energy justice seek to inform decisions around the design of energy initiatives, as well as create a discourse with which to frame support for and opposition to them [42–46].

Often central to just transition and energy justice frameworks are the three tenets of recognition, procedural, and distributional justice [47,48]. Recognition justice refers to efforts to recognize who is affected by an injustice, both at present and historically, and seeks to reconcile inequalities [49]. Procedural justice is the consideration for how decisions are made and who has power to influence them, [42], and distributional justice concerns the fair allocation of resources, wealth, and opportunities as well as the costs of hazards and externalities related to energy systems [48]. Scholars have expanded frameworks to include considerations of feminist, anti-racist, Indigenous, and postcolonial approaches [43], have added additional tenets such as restorative or cosmopolitan justice [50,51], and have applied these frameworks to both fossil fuel and renewable energy initiatives [52]. Few studies, however, have employed these frameworks to understand how renewable energy initiatives might correct or perpetuate the injustices of fossil fuel development while acknowledging the continuity of landscapes, actors, institutions, and responsibility within energy transitions.

One exception is Spangler et al. [53], who employed an energy justice framework to solar developments in Pennsylvania. Their analysis uncovers the repetition of past injustices experienced by farmers when leasing land for natural gas fracking. These include uneven distributions of benefits, risks associated with decommissioning, and leasing contracts with nondisclosure agreements that limit farmers' abilities to negotiate better terms with private companies. The study also notes how the agents of new solar developers were often the same 'landmen' responsible for securing leases for mineral exploration and drilling for previous fossil fuel development. Harry, Maltby and Szulecki [54] explore how the concept of just transition is itself being co-opted by both fossil and climate capital to delay meaningful climate action in favor of continued capital accumulation. While fossil fuel interests use the language of just transitions to position the loss of fossil fuel jobs as an injustice, the concept is also being employed to sustain capitalist social relations in the deployment of green technologies [54]. Studies like these point to the importance of differentiating between energy projects that leverage and reify established and uneven power dynamics and those that have the potential to correct them.

To this end, the application of energy justice frameworks in project permitting and development has a clear benefit toward just energy transitions. However, while energy transition frameworks provide a discourse, a vision, and tools for assessing the justice implications of energy projects, the political will to meaningfully utilize them in new energy developments is often lacking [55]. This is especially evident in fossil fuel regions where the material and cultural embeddedness of fossil fuels within landscapes, livelihoods, identities, and politics culminates in added resistance to the initiatives required to bring about more just energy futures [56–58]. We propose that prefigurative politics may offer a conceptual path through partisan disagreements around the future of energy while cultivating the ground for the growth and political acceptability of energy justice tenets as necessary considerations in new energy projects.

Prefigurative politics refers to an instance in which efforts in the present intend to shape the future [59]. In *The End of Capitalism (As We Knew It)*, J.K. Gibson-Graham [60] outline a prefigurative politic that encourages experimentation with the forms of social relation, economic practice, and modes of organization that one wishes to see in the future, beyond what lies within a status-quo organization of a capitalist economy. In their later work, they introduce the importance of the embodiment of prefigurative initiatives in "cultivating receptivity" among "reluctant subjects," or those who subscribe to mainstream notions of economic development [61]. They argue that proposals for societal or systems change require micro-demonstrations across various scales to build a required level of social acceptability for broader adoption [61].

Törnberg [62] parallels the concepts of novel technical innovations with prefigurative politics, demonstrating how the two can follow similar pathways toward societal transformation. He points to the importance of improvisation and institutionalization in both, noting that: (1) Experimentation and learning are needed to respond to changing contexts and new information; (2) Flexibility, rather than strict adherence to one predetermined vision of the future, allows for participation, deliberation, and buy-in to collective and evolving ideas of desirable futures; (3) The process of innovation creates learning and durable skills that allow for wider social cooperation and network building that can lead to the reshaping of discourses, practices, and power structures [62]. Because of these parallels, the space of technological innovation is a fertile ground for incorporating seeds of societal change. It follows then that understanding the prefigurative potential of novel energy innovations, such as HEIs, may illuminate important considerations in the pursuit of more just energy futures.

Contributing to just transition scholarship we demonstrate an approach for considering how elements of energy justice can be rendered acceptable within a political context unfavorable to climate and just transition policies. We consider prefiguration as both a political strategy in the design of energy initiatives, and also as a way to account for the transformational potential of ongoing and established initiatives. Viewing energy initiatives through enacted practices, relations, and structures, allows our evaluation to focus on and uncover what groundwork is being laid for the energy systems of the future.

4. Methods - studying hybrid energy initiatives

HEIs have the potential for prefiguring the institutions of different energy futures in historical fossil fuel regions. This research proceeds in two phases. In the first phase expert interviews provide a general understanding of the popularity of HEIs in energy transitions and how they build legitimacy through narratives of energy justice. In the second phase, two in-depth case studies demonstrate how HEIs, while narratively similar, can manifest different sociotechnical trajectories.

Research was conducted in 2022 and 2023 with human subject research approval from the first author's university. First, interviews were conducted with technological innovators working on HEIs from both industry and academia, as well as civil society actors and government officials who engage in dialogue around these initiatives more

generally (see Appendix 1). These interviews were used to understand how HEIs are being framed in energy discourse, who they are intended to benefit, and in what ways (Section 5). Interviewees were identified through an iterative web search of energy transition projects utilizing fossil fuel infrastructure in Canada and the United States.

In the second phase, two initiatives employing the same technology were identified from the interviews and selected for in-depth case studies. One, RenuWell, repurposes inactive oil and gas infrastructure for distributed solar development in Alberta, Canada. The other, Martin County Solar, constructs solar energy facilities on former coal mines, with a current project underway in Kentucky, United States. Both initiatives exist in fossil fuel regions, share the same energy technology (ground mounted solar panels), and market themselves with similar narratives of reuse and restoration.

A deeper examination of the two initiatives included additional interviews as well as content and discourse analysis. Harris and McCarthy [15] outline the challenges associated with studying technological projects that are currently ongoing, do not have clear empirical outcomes, and where much of the design and operation of the project takes place behind closed doors. Adapting the methodology outlined in their study of methane abatement technologies in Appalachian coal mines, our analysis draws on various sources of primary and secondary information to augment understandings of the initiatives captured through interviews with people familiar with them. This is particularly important in situations where project developers decline to be interviewed, as was the case with Martin County Solar. To address this absence, our study incorporates grey literature, including recorded community meetings, local newspaper articles, internal reports, court documents, public hearings, and project media releases. These materials provided details as well as an understanding of the discourses being used to represent project goals to different stakeholder groups.

In presenting each case (Section 6) we provide the relevant background and introduce the initiatives as they present themselves to the public through project and partner websites and media releases. We analyze the narratives that each initiative uses to create social license to operate within local communities and the broader society. This includes how initiatives frame the problem they intend to address, how different groups might benefit, and how the initiative illustrates the future of energy. In the case comparison (Section 7), we draw on interviews and grey literature to elaborate on the potential for each initiative to contribute to more just energy futures. We frame this analysis as a comparison between how each initiative incorporates recognition, procedural and distributional justice.

5. Hybrid energy initiatives

Expert interviews elaborated the shared characteristics of HEIs that help to explain their popularity in energy transition innovation, research, and funding. Interviewees expressed the potential of HEIs to address both the material and sociocultural aspects of energy transitions while also paving a regulatory path for the scaling of their respective innovations. As energy technologies sited on the physical footprints of fossil fuel extraction, HEIs utilize existing infrastructure and land for renewable energy generation. They also build relationships between fossil fuel and renewable energy actors, and do so while combining images, experiences, and identities associated with fossil fuels with those of renewables. Thus, HEIs are able to represent what it means to progress toward a future that builds on, both figuratively and literally, a fossil fuel past.

By their very nature, HEIs exist in fossil fuel regions and respond to these environments. Interviewees were familiar with initiatives and projects existing across fossil fuel regions in the United States: in Oklahoma, Texas, Oregon, and throughout Appalachia, and in Canada: in Alberta and Saskatchewan. Initiatives included the recovery of rare earth minerals from fossil fuel waste and the repurposing of fossil fuel infrastructure for geothermal and solar energy production, as well as for energy storage. All of which utilize lands previously under fossil fuel production.

Narratives associated with these initiatives respond to the need to appeal to stakeholders in the fossil fuel industry and industry-friendly governments, the necessity of energy transition, and the economic and environmental legacy of fossil fuel extraction. For example, technological innovators spoke of the bipartisan appeal of their respective projects. As put by a project developer working on the siting of geothermal energy production on former fossil fuel sites:

> “We've been quietly pursuing a both-end strategy across both sides of the political spectrum... the right loves it, because it's subsurface, it works with oil and gas, or alongside oil and gas, and the jobs are extremely similar, particularly in the field. The left loves it because it is renewable energy, it is paving a pathway forward”.

Interviewees also spoke of why HEIs garner the support of the oil and gas industry. Reasons included the potential for carbon credits and trading, positive public images, additional revenue streams, the extended life of fossil fuel infrastructure and delayed responsibilities pertaining to environmental liabilities, and lower electricity bills for companies continuing operations in the area.

Discourses of energy justice were also employed in conversations around HEIs. Interviewees outlined how initiatives can address legacies of environmental harm caused by fossil fuel extraction. For example, a researcher working on initiatives utilizing oil and gas wells made a direct connection between frontline communities and environmental justice:

> “One of the things that affects the expansion of renewables is the cost. You know, cost of using renewables is expensive. So, imagine that we are allowing families that live around wells to have a direct opportunity to have access to renewable energy. You know, that is environmental justice. Converting pollution or sources of pollution into a source of renewable energy for communities, even for communities that are underrepresented, or underserved. Communities that are surrounded by oil and gas wells [who] have to live in the area because they have no choice.”

Project innovators also mentioned community benefits tied to distributed energy in rural areas and on Indigenous lands, the potential uses of direct energy for community infrastructures, the continuation of lease payments and municipal taxation, and relief of budgetary burdens on taxpayers when fossil fuel actors leave behind environmental liabilities. Additionally, community and local government support for HEIs was tied to the land sparing aspects of repurposing brownfield sites. This was mentioned in contrast to solar and wind energy developments that are often criticized for their footprint and displacement of agricultural or wilderness lands.

Strongly expressed across interviews was the ability of HEIs to address climate change and the need for energy transition, while simultaneously providing ‘good-paying jobs’ and economic stimulus in fossil fuel regions. These jobs were framed as specifically prioritizing former fossil fuel workers. Initiatives situated on inactive well sites stressed the transferable skills and equipment of oil and gas service companies. Other interviewees brought up the location of initiatives in fossil fuel regions as being important for areas with current or predicted unemployment. In conversations with these project developers, technological innovators, and supporters of HEIs, neither the fossil fuel worker nor the legacies of fossil fuel infrastructure were cast aside in visions of new energy futures and the waste of fossil fuel extraction was seen as new opportunity rather than a product of mismanagement and negligence on part of government and the fossil fuel industry.

It is worth noting here that these are the words and representations of those who have a vested interest in the success of HEI projects. Our intent is to understand how these narratives position initiatives to bolster political feasibility in fossil fuel regions, meaning that these narratives are designed to appeal to those who already hold power. The

favor of the oil and gas industry and its allies likely means that projects do not appear threatening to the continuation of fossil fuel economies; communities at the front-line of fossil fuel extraction remain energy consumers vulnerable to the profit motive of private companies. We cannot understand these narratives as necessarily representing meaningful action toward more just or ecological societies. For this reason, we continue with a deeper review of two HEI projects, to examine how they draw on the materialities as well as the histories and harms of the regions in which they exist, and then compare this to the energy futures they potentiate.

6. Two cases of solar on former fossil fuel sites

Across the interviews conducted in phase 1, solar projects were a commonly referenced example of how fossil fuel sites can be redeveloped for new alternative energy projects. The use of inactive industrial sites for solar energy development dates as far back as the US Department of Energy's 1999 'Brightfields Initiative' which sought to transform abandoned and contaminated industrial sites (brownfields) in urban areas into solar energy developments (brightfields). Since then, proposals of this type have fluctuated in popularity primarily within plans for urban revitalization [63]. In recent years there has been renewed interest in 'brightfield' projects, however, the framing has shifted.

Alongside climate change and economic development, there is a greater focus on offsetting land-use competition associated with large scale wind and solar projects to preserve natural and agricultural lands [64]. Land competition is a concern widely cited in opposition to solar and wind development. This shift has brought conversations around repurposing brownfields into rural energy landscapes throughout Canada and the United States. Major environmental organizations such as the Nature Conservancy have been promoting solar on former coal mines to steer energy development away from lands deemed important for ecosystem services and nature-based tourism and recreation [65]. And in 2023, the U.S. Department of Energy announced $450 million in Bipartisan Infrastructure Law funding to pilot clean energy projects on current and former mine lands, most often located in rural areas [66].

As HEIs, solar projects on former fossil fuel sites can utilize existing utility lines, roads, and already flattened and cleared land. They can also address specific challenges associated with declining fossil fuel economies. Not only do they offset land requirements of solar projects with otherwise contaminated or altered sites, they also function to diversify the tax base in regions with fossil fuel dependent economies, provide new revenue streams to landowners, and offer retraining and employment opportunities to displaced fossil fuel workers. We turn now to an introduction of two case studies of solar projects being sited on former fossil fuel sites. Both initiatives frame themselves as trailblazing innovations in their respective regions.

6.1. The RenuWell Project

RenuWell is an initiative in southern Alberta, Canada, that seeks to re-purpose inactive oil and gas well sites for small scale (around 500 Kw) solar generation. Currently there are two pilot sites that host community scale solar projects totaling 1.5 MW of power on reclaimed well pads in the provincial orphan well inventory. Both pilot sites were developed through a partnership between RenuWell Energy Solutions, the Municipal District of Taber where they are located, and other project partners including a fossil fuel worker-led non-profit, an employee-owned solar company, and a community college. The pilots were primarily funded through government programs, but the solar generation assets are now owned and operated by a local irrigation cooperative.

The legitimacy of RenuWell is solidified by its ability to position itself within national level energy transition discourses while also responding to specific issues within the regional context. Southern Alberta has seen heavy conventional oil and gas development, however, as primary oil fields in the region have matured, production has declined. This has corresponded with an increasing trend of oil and gas companies failing to make lease payments to landowners as well as unpaid municipal taxes, which threaten the ability of rural municipalities to provide and maintain core infrastructure such as roads, bridges, and water and sewage systems [67]. Orphaned oil and gas infrastructure is also a growing problem [68] with the Alberta Government receiving ongoing criticism for its failure to hold oil and gas companies responsible for their environmental liabilities [23].

These region-specific trends are featured within RenuWell materials, citing issues related to fossil fuel liabilities as the '*oil & gas well remediation crisis*' [69,70]. The project's webpage states: "*There is a moral and economic responsibility to clean up the existing inventory of abandoned well sites and facilities, while preventing further adverse effects to watersheds, agricultural lands and rural communities*". The initiative specifically addresses the economic impacts of a declining fossil fuel industry such as lost tax revenue, employment, and lease payments to landowners [71]. Though many would argue that fossil fuel corporations are culpable in the harm caused by abandoned infrastructure and forgone debts, the initiative instead frames energy market volatility as something that impacts all of Canada, the fossil fuel sector included [72].

Initiative materials reference issues arising from ongoing energy transitions, mainly land competition between renewable energy development and agriculture [69,70,73]. They tend to skirt around mentions of climate change and instead focus on the current energy system's need for costly retrofits that are passed on to consumers and the inefficiencies of large-scale centralized power stations located far from population centers. Although, some project partners do have specific mandates toward climate neutrality, climate resilience, and reducing greenhouse gas emissions, and these partners frame RenuWell around energy transition using those terms [69,71].

The stated beneficiaries of RenuWell align with the problem framings of the initiative. There is a focus on benefits to landowners and rural municipalities, as well as revenue flows toward the cooperative owners of the solar projects [69,70]. Fossil fuel corporations are also featured prominently by project partners, with intended benefits directed through reductions in legally mandated reclamation costs, as well as through the potential creation of low-cost energy to support ongoing fossil fuel production [69,70,73]. The project also mentions a range of benefits related to the transfer of knowledge. Through an associated program offered by project partners, oil and gas workers and Indigenous community members were provided training in solar installation, specifically on well sites.

RenuWell envisions the use of abandoned well pads for community owned solar generation as a scalable option for supporting energy security and local control in energy production [74]. Beyond the technology deployment itself, the project team recognized the need for knowledge around appropriate siting, municipal permitting, and ownership options. To this end, the initiative also created a guidebook for other municipalities in Alberta to navigate the utilization of orphaned and inactive well sites for community solar generation [75].

6.2. The Martin County Solar Project

In eastern Kentucky a 200 MW merchant solar project is being constructed on 1200 acres of the former Martiki coal mine in Martin County. The development is framed as one of the largest utility-scale solar projects in the United States, a pilot for similar projects planned across Appalachia. Demonstrating the feasibility of solar on coal mines is an important step for similar projects in the future, as these developments can carry an extra degree of risk associated with predicting cost structures and navigating regulatory requirements. Martin County Solar is being developed by Savion, a subsidiary of Royal Dutch Shell (Shell), a multinational oil and gas company, in partnership with Edelen Renewables. Edelen Renewables is a solar energy company that coined the term "social impact solar" to describe a solar development that has positive impacts for the communities in which it takes place.

The legitimacy framing of Martin County Solar centers mainly around the region's history in coal mining and its need for economic revitalization. This is coupled with the claim that solar energy development can provide a kind of repayment for the hard work of coal miners and reconciliation for the damages wrought by historical coal extraction. Coal production in the United States has seen long-term declines, the consequences of which have been disproportionately borne by historical coal communities who have relied on the industry for labor, income, and public revenues. With coal industry jobs also in decline in Central Appalachia, average wages and salaries have become the lowest in the region [76]. Eastern Kentucky has a deep coal heritage and shares the Appalachian history of resource extraction and exploitation [16]. Here, the industry has left over 180 thousand acres of unreclaimed mine lands, at times using bankruptcy protections to skirt reclamation obligations [12]. This has left the state government to pay for clean-ups that far outweigh its financial capability.

Martin County in particular, has suffered chronic and acute environmental damages caused by coal extraction. In 2000, a 72-acre coal waste impoundment ruptured spilling more than 300 million gallons of toxic waste into two nearby creeks, killing aquatic life, disrupting public water supplies, and flooding residences and properties [77]. The county has also experienced issues related to aging public infrastructure combined with a reduced tax base, steady employment declines and a persistently high poverty rate, the 6th highest in the country [78,79].

Though issues specific to Martin County are not addressed in project materials, developers respond to greater economic trends within Appalachian coal communities. They position themselves as moral actors, helping to "*square the deal*" [80], and ensuring that "*the people who powered the industrial development of this country for 100 years have a place in a greener economy*" [81]. County officials echo this narrative, conjuring the identity of Appalachians as being at the forefront of energy development throughout history, and positioning Martin County Solar as a chance for families and communities to stay in the region [82]. Similar to RenuWell, direct references to climate change are absent from the project webpage, however, partners such as Edelen Renewables do make mention of the positive climate impacts of renewable energy adoption [80].

Project benefits are framed in economic terms. The initiative webpage provides a general outline of typical benefits of solar projects, including economic development opportunities for landowners, tax revenues for local governments, jobs, and consumer benefits such as stable electricity costs and the diversification of the electricity grid. In media interviews with developers, the people of Martin County are framed as the main project beneficiaries with a dominant focus on the 350 jobs the project will create during construction, with priority given to displaced coal miners and local residents [83]. The project also has a payment in lieu of taxes (PILT) agreement with Martin County for $1500/MW, annually over 30 years - equating up to $30,000 a year. Savion also donated $100,000 to Martin County High School to build their own solar array.

Project developers envision a future with increased reliance on renewable energy through large utility-scale solar projects. In a media interview the founder and CEO of Edelen Renewables shared his view that "*the electrification of everything is going to be the primary economic driver for the next 50 or 100 years. This is a fact.*" [84]. While appealing to investors, Edelen Renewables also frames *'forgotten communities'* of the United States- or communities with historical economic reliance on fossil fuel extraction as ground zero for transition toward solar energy production [80]. While the need for economic stimulus in these communities is a central point in the company's marketing, their vision stops short of recognizing the harm and dispossession that led to communities' economic reliance, particularly in Appalachia, or how these histories will be addressed within solar development. Both Savion and Edelen Renewables have multiple utility-scale solar developments across the United States.

7. Case comparison

In this section we compare the two initiatives and their respective pilot projects to illustrate how the design of energy initiatives, even while using the same technology, can employ different conceptualizations of recognition, procedural and distributional justice. We explore how these initiatives deal with past harms, invite community engagement, and how they maintain or reconfigure existing allocations of resources and power.

7.1. Recognition justice: recognizing and addressing past harms

In our analysis, we incorporate not only recognition, but also elements of restorative justice by assessing how past harms are recognized and also how they are actionably addressed within new energy projects. As projects are ongoing, we conceptualize an initiative's ability to address past harms as the extent to which people and communities who have been harmed by previous fossil fuel extraction had voice within the design of the new projects and thus the ability to describe what might be done in reconciliation. This is a significant consideration for initiatives that are physically sited on the lands of fossil fuel extraction and rely heavily on the people and landscapes of fossil fuel regions to underscore the importance of their projects. Both cases approached past harms by making efforts to transform degraded lands into new low-carbon energy projects and direct benefits to those who have experienced injustices. However, the extent to which these communities were able to engage with project design differed greatly.

During project planning RenuWell explicitly included the input of those harmed by previous fossil fuel extraction, such as Indigenous communities, landowners, and rural municipalities. The initiative took specific actions to incorporate Indigenous peoples and knowledges and project partners identify the potential for these innovations to contribute to energy sovereignty and security for Indigenous and remote communities [71]. Retraining programs were offered to former fossil fuel workers as well as Indigenous peoples in the region with the intention of empowering workers and communities to combat environmental racism and to work toward healing and reconciliation [85]. Project developers also worked with the Orphan Well Association, landowners, and the municipality to identify sites for development where fossil fuel actors had abandoned clean-up obligations rather than sites where fossil fuel companies themselves might benefit from delaying responsibilities for decommissioning.

Martin County Solar stated the intention of repaying the country's '*debt to the people and communities that powered the industrial development of America for a century: our miners and coal communities*' [86]. However, it is uncertain as to whether miners or coal communities from Martin County were involved in the planning or design of the solar project. Evidence of actions taken toward recognition justice focused on providing tax revenue for communities suffering from the decline of coal, and offering jobs specifically geared toward displaced coal miners and residents [87]. This is in line with shallow conceptualizations of just transition and the long-standing focus around training fossil fuel workers as renewable energy workers [88]. Notably however, there was an absence of any binding commitments around employment and county benefits will be delivered through a 30-year PILT agreement that locks in a set payment without adjustments for inflation or future fluctuations in energy costs for citizens.

7.2. Procedural justice: community engagement

The different ways these initiatives were designed and executed impacts how power and agency was maintained or renegotiated. Related closely to recognition justice, procedural justice focuses on who was included in the decision-making process and whether the process was fair, transparent, and inclusive.

As explained by project developers, the idea for the RenuWell

initiative came from the impending end of the lease payments for an oil well on family land. However, the project team quickly grew to incorporate people and organizations with varied perspectives on which problems, and whose problems, this technological initiative could be designed to address. This included perspectives of the energy regulator, fossil fuel and renewable industries, landowners and farmers, rural municipalities, Indigenous communities, and climate and justice-oriented non-profits. In this, the design of the RenuWell pilot was able to account for the specific political and social contexts of where the project was sited and could respond to the needs and desires of a broader subset of those who may have experienced harm at the hands of past oil and gas development. This happened outside of regulated requirements for community engagement. The seed funding for the project also came from the Municipal Climate Change Action Centre which is mandated to help municipalities lower energy costs and improve community resilience [69]. This required the project developers to seek and consider the needs and desires of the municipality from the beginning of project planning.

Though the Martin County Solar Project describes itself as a social enterprise endeavor helping the communities in Martin County, the project was designed without their input. This can be seen in the project timeline presented by Savion and in case filings to the Kentucky Public Service Commission [89]. This was also underscored in conversation with a community advocate familiar with the project: *"Just from the get go, I mean, this project was conceived and developed outside of the community, right? It wasn't a hey, let's put solar here? and how do you want to construct it? that just wasn't the model."* Though the project began in 2019, it was not until the fall of 2021 that residents' input was meaningfully sought. Furthermore, this came only when civil society organizations recognized the need for increased public knowledge around the project. A team of academics and community advocates gathered the questions and priorities of community members so that they could be communicated to the developers [90]. Thus, community consultation was performed by a group independent of the developers, while the developers only followed the minimum guidelines set out by the permitting process.

While RenuWell welcomed and integrated an expanded input from different communities during project design, Martin County Solar received community input after the main structure of the project was already in place. When community consultations are sought after the design of a project, any action that begins to meet the community's stated desires exists only as an addendum bounded within an already determined suite of possibilities. This limits how community needs, desires, and perspectives on past harms and the possibility for reparation can be incorporated.

7.3. Distributional justice: resources and economic control

The way that these initiatives were designed also determines the flows of benefits and burdens. One of the primary differences between the RenuWell project and the Martin County Solar project is their economic structures, which impact who benefits both from the generation of solar electricity and from its use. RenuWell focuses on distributed solar, while Martin County Solar develops merchant solar.

Distributed solar, by nature, is smaller scale, decentralized, and located near the point of end use. Being near the point of end use means these projects can provide electricity without the service or upgrading of transmission lines, which are often controlled by large utility corporations. Because of this, distributed solar can reduce dependency on centralized utilities and buffer consumers from rate hikes and volatile energy markets. Communities can have a say in, and benefit from, local energy production, challenging the traditional top-down energy model. This sentiment was echoed in conversation with RenuWell project developers - *"I believe that it's a lot about transitioning from being dependent on you know, megaprojects and major consolidated economic and political power groups, to something that can be more diversified and more in control and in harmony with the local community."* As previously mentioned, the assets of the RenuWell project pilots are owned and operated by a local irrigation cooperative who directly benefits from the 2 MW of electricity generation to deliver water to farmers in Southern Alberta [91].

Merchant solar is provided by independent power producers that sell power on the wholesale market. The large scale of merchant solar projects often requires major investors and government subsidies during development. While governments often prioritize large scale projects to address the urgent need for energy transition, developer and investor buy-in is based on long-term profits. These projects fit into the already established processes, norms, and relationships of other large energy projects, such as those using fossil fuels. As such, developers are often traditionally structured corporations and can even be the same corporations that have benefited from fossil fuel extraction - as is the case with Shell's involvement in Martin County Solar. In this arrangement, direct beneficiaries are primarily large energy companies and investors. The first 100 MW of power generated by the project is being purchased for an undisclosed amount by the Japanese car manufacturer, Toyota, to offset their carbon emissions, while profits flow to project developers. From a distributional justice perspective, this approach does little to redistribute resources to local communities and instead reinforces existing power structures.

8. Discussion: prefiguring energy futures

Considering the scaling potential of novel energy innovations, assessing the doors they open, or close, toward the realization of more radical transformations is a way of mapping pathways toward more just energy futures. Here we endeavor to identify the seeds of more radical change within our two case study initiatives and their relevance to energy transitions in fossil fuel regions.

The past is a critical consideration in the prefiguring of just energy futures, for without meaningful consideration we risk reproducing inequalities [15]. In addressing the economic harms of declining fossil fuel industries, both initiatives prioritized job creation as economic stimulus for the regions in which their projects exist. In particular, initiatives drew attention to the re-employment or retraining of fossil fuel workers. While the displacement of workers is a major concern in the phase-out of fossil fuels, this focus ignores not only differences in income and regional availability of renewable energy jobs [92], but also existing inequalities - women and people of color are underrepresented in renewable industries much the same as in fossil fuels [49]. Furthermore, when actions taken to address past harms are heavily focused on job opportunities, this wrongly equates reparation to participation in the power relations of wage labor. As explicitly seen in studies of environmental justice, communities most harmed by past extractive industries may prefer interventions that address inequality, rather than simply provide jobs in the new 'just' paradigm [93].

RenuWell took an important step beyond jobs, expanding the initiative's potential for recognition justice. The initiative sought to understand how their innovation could be directly utilized by the communities harmed by settler colonization and those experiencing economic declines due to the fossil fuel industry's contraction. Further, the projects are adaptable to diverse ownership structures—such as private ownership, community, and cooperative models— making them more responsive to context and able to channel a range of different values. In this, scaling can be motivated not only by profit, but by goals such as energy sovereignty, security, sustainability, or democracy [94]. RenuWell, in its explicit support for different configurations and relations of power, is creating opportunities for experimentation with forms of social relation, economic practice, and modes of organization. Energy innovations that allow for meaningful community participation and restorative action, flexibility, plural values, and experimentation can prefigure energy futures shaped to serve diverse interests and can support the return of agency and power to previously exploited communities. Conversely, when participation in project design and deployment is limited to energy capital - investors and corporations that pursue

profit through the commodification of energy - scalability becomes synonymous with profitability; the incorporation of values that might decrease profits become prohibitive [95].

Prefiguring procedural energy justice could mean enacting meaningful participation in project development beyond that which is a regulated requirement. We can also think of it as opening space in regulatory frameworks for the deployment and scaling of alternative energy projects with more radical prefigurative potential. Regulatory environments around energy project permitting and distribution can have major impacts on the future political economies of energy systems [96]. As early demonstrations of their respective initiatives, both projects are helping to shape the regulatory environments within the 'transit' of energy transition. The current regulatory environments in the US and Canada are variable by region and generally focus on utility-scale solar or micro-scale solar on individual businesses and homes rather than mid-sized community-scale projects [3,97]. RenuWell mapped the terrain of current energy policy in Alberta and identified the changes needed to allow for more community-scale distributed projects. This challenges the centralization of energy production and the dominance of major utility companies in their ownership and control of energy transmission infrastructure. It also begins to normalize more alternative forms of energy production within an otherwise conventional energy market. RenuWell also paid particular attention to how regulatory changes could be made for repurposing well pads without creating loopholes for oil and gas companies to off-load their environmental liabilities. Martin County Solar, by siting solar on a former coal mine, did demonstrate the economic feasibility of such projects and helped to smooth frictions in the current permitting process. However, by leveraging just transition narratives alongside the abandoned assets of the coal industry and coal communities, Martin County Solar rebrands major energy projects while replicating the business models, investor focused profit structures, and weak engagement practices criticized in past extractive projects.

Initiatives have the power to prefigure the practices and relationships of the future; and often the power dynamics of relationships determines the flow of benefits [98]. Both initiatives created networks of partners, transferable knowledge, and durable skills for the scaling of future projects and the creation of future benefits. Notably, and early in the planning process, RenuWell fostered meaningful partnerships beyond private corporations and the state, allowing diverse voices and needs to shape the intended beneficiaries. Martin County Solar reified the practices and relationships of energy development favored by large for-profit energy corporations and their own concentration of wealth. While in both initiatives power remained weighted toward those with capital means, opportunities for collective decision making or even collective ownership, as demonstrated by RenuWell, introduce practices of deliberation and consideration for the weighting of various viewpoints [99]. Building these skills in arenas of any size should not be understated in efforts to create more just futures.

Viewing these energy initiatives for the institutions that they prefigure allows us to consider their contributions to ongoing and unfolding just transitions. How initiatives acknowledge and begin to address past harms, how they adjust distributions of power, and which relationships they help to strengthen contribute to a new context in which successive energy projects can be designed and find legitimacy. This is important both in how communities are able to meet needs and exercise agency, and in setting norms around how previously exploited land is redeveloped.

9. Conclusion

Enacting just and ecological futures entails a radical rethinking of the way societies produce, consume, and relate to energy. However, this is complicated by deep material and sociocultural histories that have coevolved alongside abundant fossil energy and a rising petro-politic that attempts to wed identities and conceptualizations of well-being to the extraction and use of oil, gas, and coal. Our study illustrates hopeful points of intervention within energy transitions through the design and implementation of energy initiatives, but also the necessity of interrogating justice claims in renewable energy development. Within regions tightly bound with fossil fuels, the inclusion of small reforms that begin to challenge concentrated power and clear paths toward more transformational changes are positive acts in the construction of more just energy futures. Conversely, energy transition initiatives that fail to account for past harms, do not shift economic control toward communities, and utilize a status quo model of energy development will continue to reproduce exploitative cycles.

As initiatives that site projects on land previously used for extractive activities and in regions where cultures and social institutions have been shaped by such activities, the design of HEIs to prefigure just energy futures is tentatively promising. However, just transitions require more than the remediation of degraded landscapes, the production of low-carbon energy, and the creation of wage labor jobs. They require an acknowledgement and repair of past injustices, a redistribution of economic and decision-making power, and the strengthening of institutions based on relationship and democracy. Our work introduced and examined HEIs in fossil fuel regions to contemplate these requirements particularly within political and cultural contexts that may present barriers to energy transition.

The prefigurative potential of energy innovations offers an avenue to evaluate and track transformation within the 'transit' of transitions. We believe this approach can help fortify against the co-optation of visions of just and ecological futures as a tactic for exploitative projects to build legitimacy. In the same way that HEIs offers a cultural and material bridge for renewable energy projects in fossil fuel regions, prefigurative politics offers a path for designing energy transition initiatives that build toward a future that may seem out of reach in the present.

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Megan Egler: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Conceptualization. **Lindsay Barbieri:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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Appendix 1

Interviews were conducted with technological innovators working on hybrid energy initiatives from both industry and academia, as well as industry and civil society actors, and government officials who engage in dialogue around hybrid energy initiatives.

Interview	Hybrid energy initiative
Civil society - just transition organization	Solar energy on fossil fuel sites
Civil society - community advocate	Solar energy on fossil fuel sites
Fossil fuel industry association	Solar energy on fossil fuel sites
Fossil fuel company	Solar energy on fossil fuel sites
Government - economic development	Solar energy on fossil fuel sites
Government - energy programs	Solar energy on fossil fuel sites
Innovator - industry	Solar energy on fossil fuel sites
Oil and gas worker in retraining program	Solar energy on fossil fuel sites
Coal industry labor union representative	Solar energy on fossil fuel sites
Academia - Dept. mining engineering	Rare earth minerals from fossil fuel waste
Essential minerals association	Rare earth minerals from fossil fuel waste
Innovator - industry	Hydropower on fossil fuel sites
Fossil fuel industry association	Hybrid energy initiatives - general
Innovator - government researcher	Hybrid energy initiatives - general
Innovator - government researcher	Hybrid energy initiatives - general
Academia - Dept. petroleum engineering	Geothermal on fossil fuel sites
Innovator - industry	Geothermal on fossil fuel sites
Innovator - industry	Geothermal on fossil fuel sites

Data availability

The data that has been used is confidential.

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